# Supplementary Information

## Surface-engineered core-shell upconversion nanoparticles for effective hypericin delivery and multimodal imaging

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**Degradation of DPBF by free and conjugated Hyp**

To compare the singlet oxygen generation, i.e. the PDT efficiency for both free Hyp and Hyp conjugated on the particle surface, the amino salt of Hyp was chosen as a model. Briefly, a stock solution of Hyp in ethanol and DMSO (182 µl; 0.08 mg/ml) was mixed with PDMA (5.1 mg) and a 10 % aqueous NaOH solution (5 µl). Solutions of free and conjugated Hyp (0.0079 µmol/ml) in ethanol/DMSO (50/50 v/v) were mixed with 0.02 mmol DPBF in ethanol/DMSO (50/50 v/v) to a volume of 2 ml, transferred to quartz cuvettes, which were sealed and irradiated with 590 nm light () for 2 h in the dark. A DPBF solution of the same concentration was used as a control. The degradation of DPBF was calculated from the UV-Vis spectra of Hyp solutions measured at different time intervals.

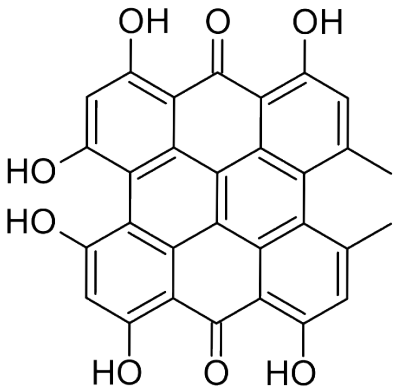


**Figure S1**. Structure of hypericin.

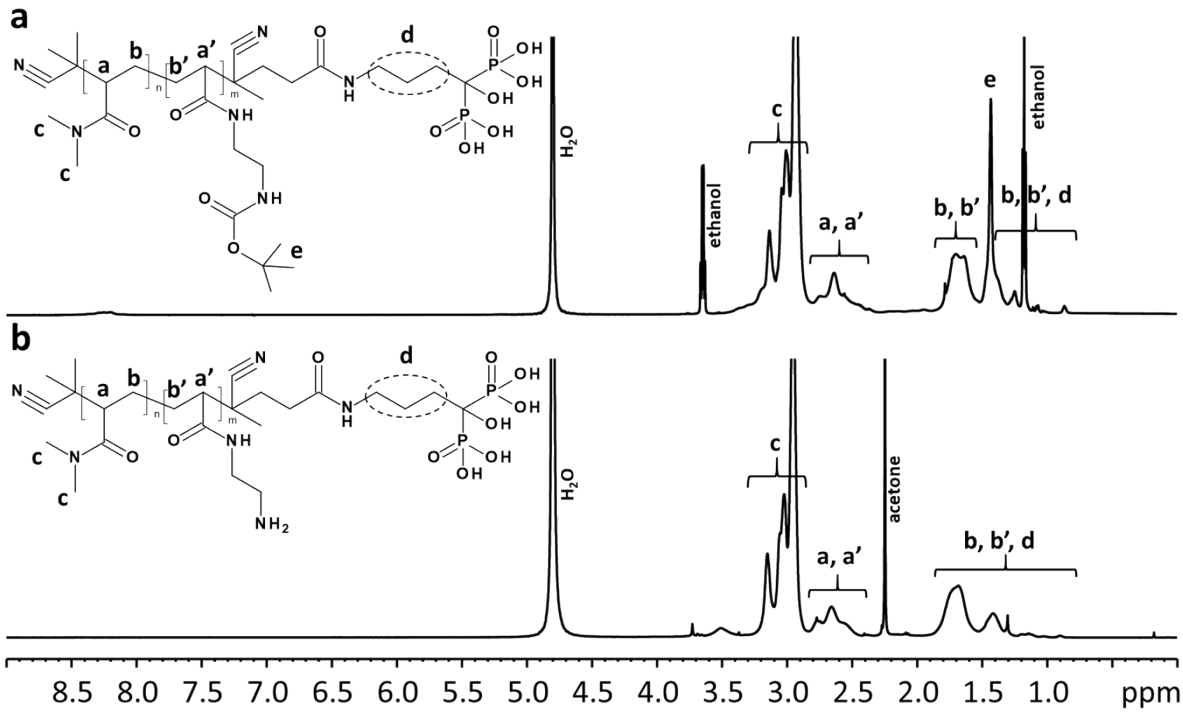


**Figure S2.** $^{1}$H NMR spectra of (a) P(DMA-AEC-Boc)-Ale and (b) P(DMA-AEA)-Ale copolymers.

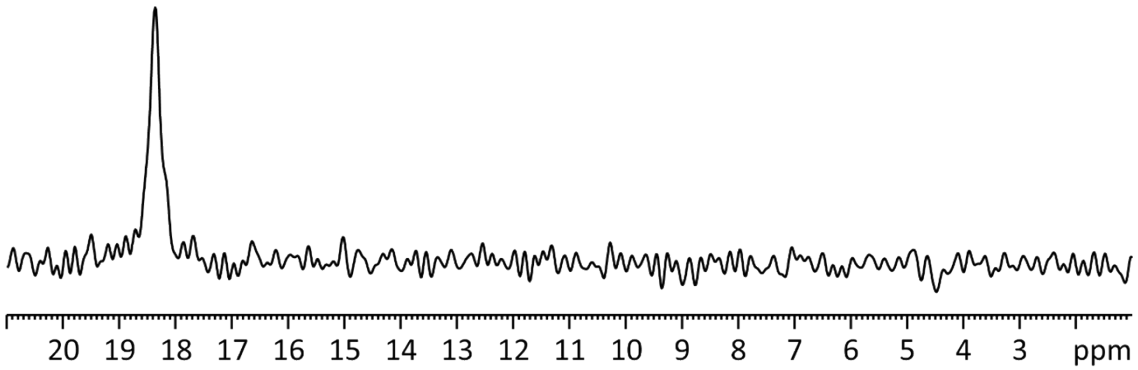


**Figure S3.** $^{31}$P NMR spectrum of P(DMA-AEA)-Ale copolymer.

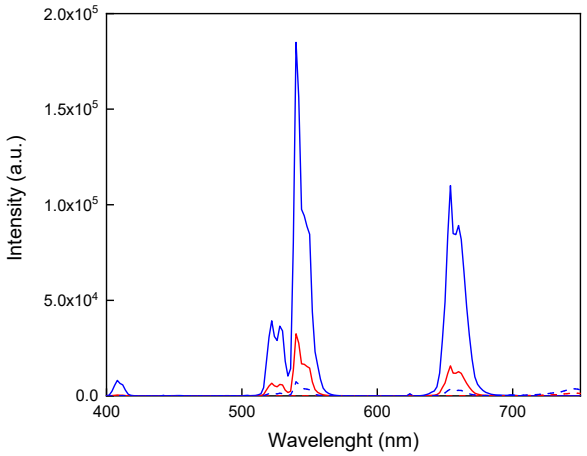


**Figure S4**. Upconversion luminescence spectra of C-UCNPs (red) and CS-UCNPs (blue) in water (1 mg/ml) excited at 980 nm (solid) and 808 nm (dash) with a laser power of 0.6 W.

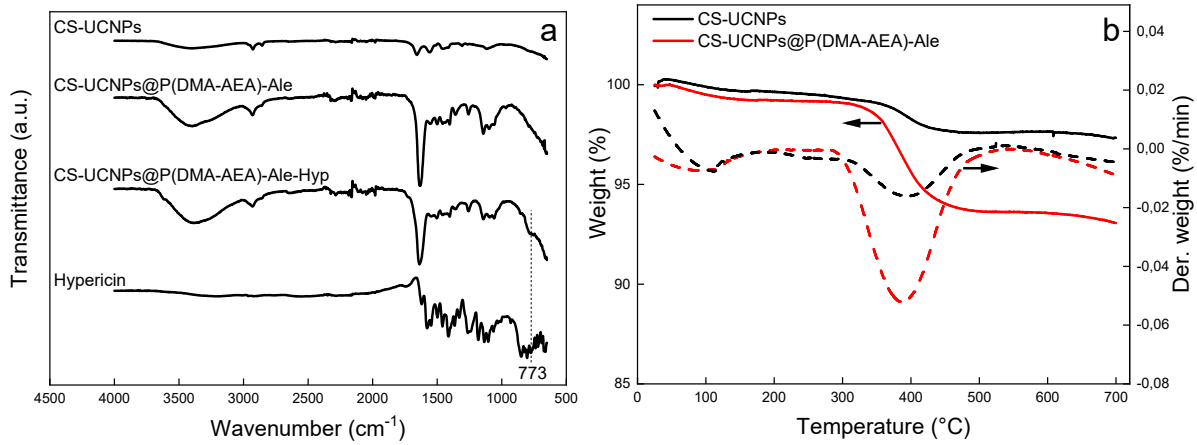


**Figure S5.** (a) ATR-FTIR spectra of CS-UCNPs, CS-UCNP@P(DMA-AEA)-Ale, CS-UCNP@P(DMA-AEA)-Ale-Hyp and hypericin. (b) Thermograms (solid line) and their first derivative (dash line) of CS-UCNPs and CS-UCNP@P(DMA-AEA)-Ale nanoparticles.

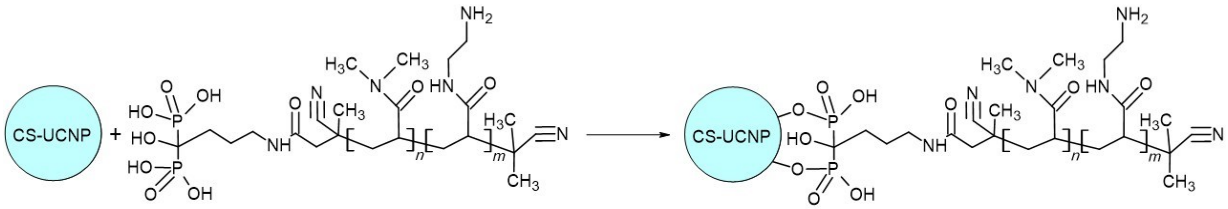


**Figure S6.** Preparation of CS-UCNP@P(DMA-AEA)-Ale nanoparticles.

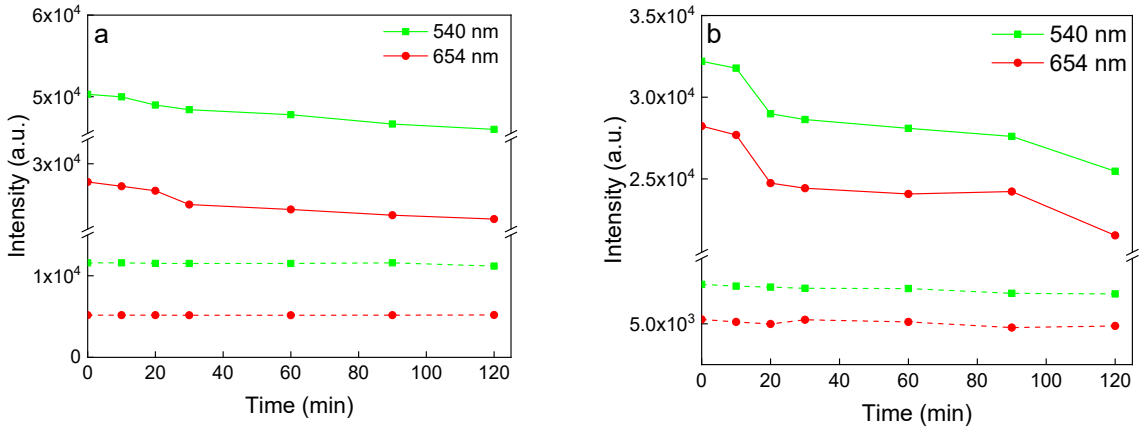


**Figure S7.** Time dependence of green (540 nm) and red (654 nm) upconversion emission intensity of (a) CS-UCNP@P(DMA-AEA)-Ale and (b) CS-UCNP@P(DMA-AEA)-Ale-Hyp nanoparticles in water excited at 808 nm (dash) and 980 nm (solid).

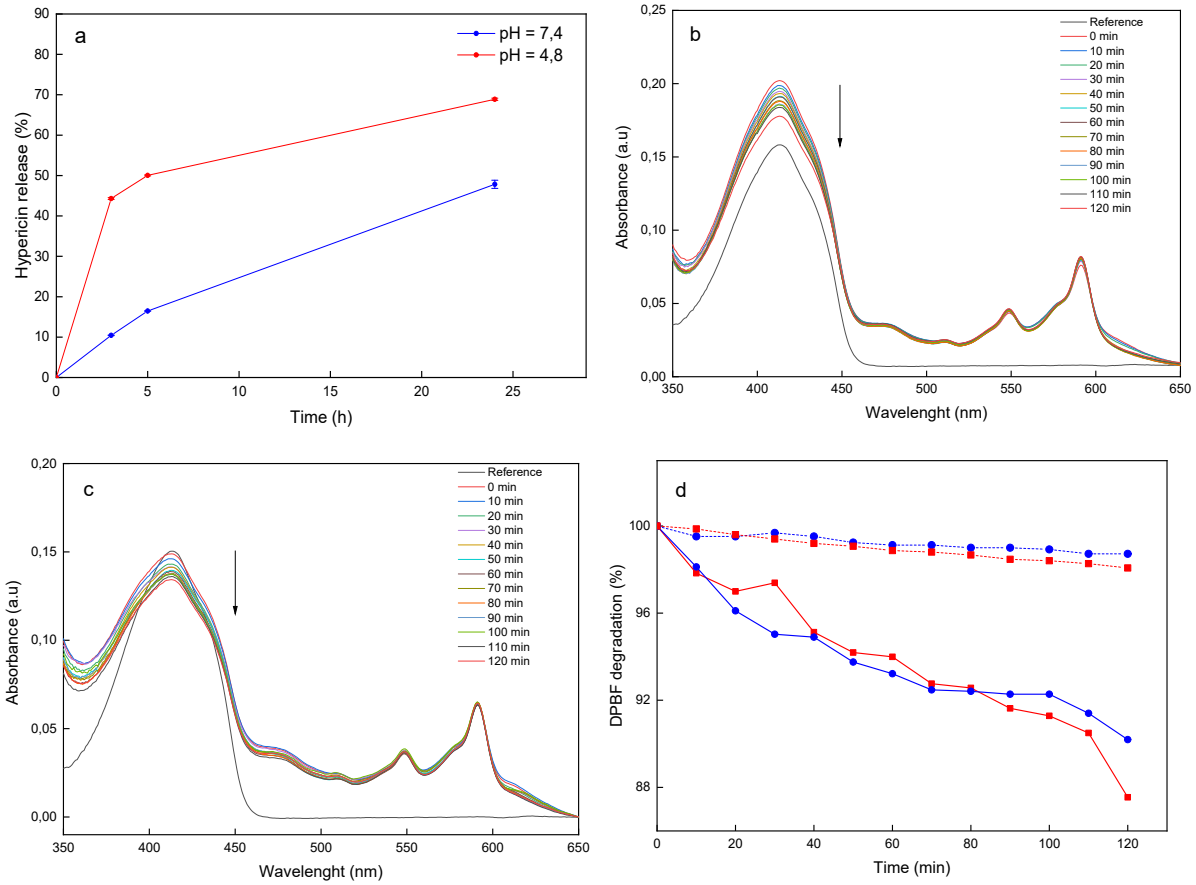


**Figure S8.** (a) Hyp release from CS-UCNP@P(DMA-AEA)-Ale-Hyp particles at different pH measured at 602 nm. UV/VIS spectra of degradation of DPBF in (b) ethanol/acetate buffer (pH = 4.8) and (c) ethanol/MOPSO buffer (pH = 7.4) under laser exposure (980 nm; 2.11 W/cm$^2$) in the presence of CS-UCNP@P(DMA-AEA)-Ale-Hyp particles and (d) degradation rate of DPBF at pH = 4.8 (red) and pH = 7.4 (blue) under the same laser exposure in the presence (solid) and the absence of particles (dash).

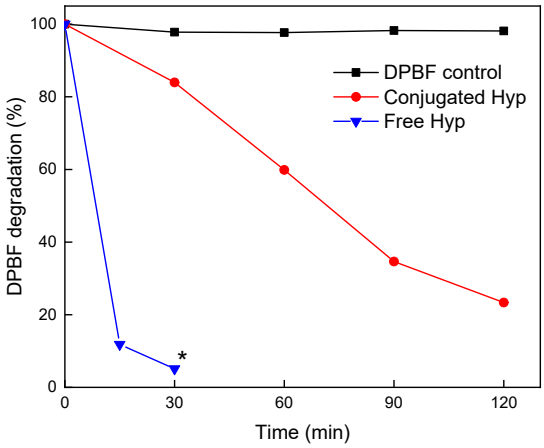


**Figure S9.** Degradation of DPBF in the presence of free and conjugated Hyp irradiated at 590 nm. * The experiment was stopped due to the high degradation rate.